

The Effects of Mindfulness Training on Children's Attention Skills

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The Effects of Mindfulness Training on Children's Attention Skills

ORIGINAL PAPER

Introduction: Mindfulness Trainings (MT) have been shown to enhance participants' attention skills by improving attention networks as well as supporting emotion regulation which may otherwise lead to distractions or biased attention. While research in adult populations shows promising results, only a few studies have examined the effects of MT in children. This investigation aims to address the gap in research by assessing the effects of mindfulness training for children at two schools (school 1: N=24, aged 9-12; school 2: N=63, age 8-11).

Methods: Children were assessed on the Attention Network Task - Interference (ANT-I; N=91) and on an Attention Control Task (N=91). Furthermore, parents filled in questionnaires rating children's executive functions. Measurements were assessed before and immediately after the 5-6-week training. School 1 MT group (N=12) was compared to an active reading control group (N=12), and school 2 MT group (N=24) was compared to an active reading control group (N=22) as well as a passive control group (N=21).

Results: Performance on the ANT-I and on the Attention Control Task did not show a significant main effect for training group. In order to explore whether children's emotional regulation improved attention, children's performance was grouped in high and low emotional control group, which did not differ significantly pre- and post-test on main effects on ANT-I.

Conclusion: While mindfulness trainings hold many promises in adult populations, this study was unable to show that mindfulness training in children enhances their attentional control. This may be due to the young age of the children or the relatively short period of MT. Further studies need to be conducted in order for sufficient conclusions to be drawn about the effects of mindfulness training with children.

Keywords: mindfulness, emotions, attention

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INTRODUCTION

A growing body of research shows longitudinal relations between children's executive functions (such as attention, inhibition, working memory and planning), social-emotional development and their academic performance (Blair & Razza, 2007; Hughes, Cutting, & Dunn, 2001; Riggs, Blair, & Greenberg, 2003).. The need to support children especially in their attentional capacities is best reflected in the growing body of research investigating how children's attention skills can be enhanced. While several trainings, such as visuo-spatial computer games (Thorell, Lindqvist, Bergman, Bohlin, & Klingberg, 2008) and the Attention Process Training (Kerns, Esso, & Thompson, 1999) have been developed, many trainings do not take the mediating role of emotions on attention into account. For example, anxiety has been shown to affect attentional biases to threatening stimuli in children, sometimes at the cost of attention for other potentially relevant information (Ehrenreich & Gross, 2002; Taghavi, Neshat-Doost, Moradi, Yule, & Dalgleish, 1999). It is therefore not enough to only train attention processes. In order to enable children to fully access their attention skills they must also be supported in their emotion regulation. A training which addresses both emotion regulation *and* attention networks is mindfulness based training (MT). MT has been shown to improve attention networks in adult populations (Jha, et al., 2007), and to reduce negative emotional affect (Tang et al., 2007; Arch & Craske, 2006).

This study examined the effects of MT on children's attention skills using two measures of attention: the Attention Network Test (ANT) and an Attentional Control Task (Alberts, Martijn, Greb, Merckelbach & de Vries, 2007), which are described below. Furthermore, the link between emotional control and attention was examined by assessing whether children with low emotional control (as rated by parent-rated questionnaires) benefit more from MT than children with high emotional control. Before further explaining the design and tasks used in the present study, Posner's attention network model, on which the tests used in the current study are based, will be explained. This will be followed by a discussion on how emotional states can influence attention, which is investigated in the current study by examining a possible interaction between emotional control and MT. Subsequently, the design is outlined in detail. Finally, the results are discussed.

Attention: A Tripartite Network Model and the Effects of Emotions on Attention

According to Posner's attention network theory (Posner & Boies, 1971; Posner & Petersen, 1990), three different attention networks can be distinguished: the executive control network, the orienting network and the alerting network. While the executive control network is active when a person faces a situation that involves overcoming habitual actions and giving novel responses (Posner & Petersen, 1990), the orienting network, on the other hand, selects where to attend to in the environment (Posner & Petersen, 1990). Finally, the alerting network creates an internal state of high sensitivity to incoming stimuli (Posner, 2008).

In children, these three networks appear to mature at different ages. Trick and Enns (1998) report some very early development of alerting before the age of six with little improvements after this, while others such as Rueda and colleagues (2004) report that the alerting network seems to be mature by the age of four years already. In contrast, while simple orienting such as moving the eyes in response to a flash matures early (Baijal, Jha, Kiyonaga, Singh, & Srinivasan, 2011), more complex orienting processes such as the ability to select relevant information during distraction do not reach adult levels until the age of nine years (Huang-Pollock, Mikamo, Pfiffner, & McBurnett, 2007). Finally, the third type, executive control as measured by the ANT-I is thought to only be fully mature at age twenty-five (Rueda et al., 2004).

The efficiency of these individual networks is assessed during the Attention Network Test (see Figure 1). In this test, the executive control network is assessed via a 'flanker' task. A target (arrow or fish) is presented at every trial, with flankers that can either point in the target's direction (congruent condition) or the opposite direction (incongruent condition). Participants indicate by pressing one of two keyboard keys which direction the target is pointing at. In general, the reaction times in the congruent condition will be faster than those in the incongruent condition, since the incongruent condition will invoke some interference. The flanker task is preceded by a spatial cueing task, which assesses the efficiency of the orienting network. Here, an asterisk can appear in the position of the target (valid cue), in a different location (invalid cue), or it not will not appear at all (neutral cue). Thus, a valid cue will lead the subject to orient attention to the target location so that a very fast response can be given. An invalid cue will draw attention away from the target location so that disengagement of attention is required first before attention can be shifted to the target location. This disengaging takes time and the difference in reaction time (RT) between invalid and valid trials reflects the time needed to disengage and shift attention. The smaller the difference in RT between invalid and valid conditions, the more efficient one is in disengaging and orienting (shifting) attention across space. Finally, the efficiency of the alerting network can be assessed during trials with an audio cue that prepares the participant to respond to a visual cue at an unknown location (Fan et al., 2002).

It is important to note that these three networks can also be influenced by the emotional state of a person (Vasey, Daleiden, Williams, & Brown, 1995; Vasey, El-Hag, & Daleiden, 1996; Ehrenreich & Gross, 2002). In Posner's model of selective attention, Posner compares attention to a spotlight which illuminates certain locations at the expense of other, non-attended spatial locations (Posner,

1978; Treisman, 1969). Emotions can sometimes influence where this spotlight falls, allocating attention towards salient stimuli that are relevant to a person's internal state (Crick & Dodge, 1994) and guiding subsequent judgements and behaviours (Fisk & Taylor, 1991; Pashler, Johnston, & Ruthruff, 2001). For example, in an amended Stroop-task with spider-phobic children aged six and seven years, children demonstrated slower reaction-times for colour naming of spider-relevant words, while control children displayed no such bias (Martin, Horder & Jones, 1992). Additionally, non-clinical high-anxious children displayed a colour-naming bias associated with the presentation of general threatening stimuli, while low-anxious children demonstrated interference in colour naming of threatening words when an immediate stressor (e.g. an injection) was presented (Kindt, Brosschot, and Everaerd, 1997). Given the influence of emotions on attention, it follows that to effectively train children's attention one must also train their emotional regulation. MTs are one of the few trainings which do this. In the following section, the effects of MT on emotions and attention will be explored.

The Effects of Mindfulness on the Attention Networks and Emotional Regulation

Mindfulness can be defined as “the awareness that emerges through paying attention on purpose, in the present moment, and nonjudgmentally to the unfolding of experience moment by moment” (Kabat-Zinn, 1994, p.144). Most mindfulness trainings focus on learning two kinds of meditation. The first one, called “concentrative” or Focused Attention (FA) meditation, involves training to focus attention on one single aspect such as the breath or a mantra. The second one is called “receptive” or Open Monitoring (OM) meditation and involves the attention being kept in the present moment of experience without limiting or directing it in any way. Extraneous stimuli are considered distractors in FA meditation, while in OM meditation attention is open towards all stimuli experiences (Jha et al., 2007).

Several studies suggest that FA meditation trains the executive control network and the orienting network, since it relies on the exclusion of unwanted stimuli and (re-)focusing on the desired object of control. In adult populations, case-control studies have shown that experienced practitioners of FA meditation demonstrated better executive control scores on the ANT-I than meditation-naïve participants did. Furthermore, eight weeks participating in a Mindfulness Based Stress Reduction (MBSR) training improved participants' orienting scores compared to those of an inactive control group (Jha et al., 2007). Following a brief MT intervention (twenty minutes a day over five days of training), participants significantly improved their executive control scores on the ANT-I compared to a control group (Tang et al., 2007).

Whereas FA meditation improves orienting and control networks, OM meditation appears to improve the alerting network. Experienced adult meditators participating in an OM mindfulness training improved their alerting scores on the ANT-I relative to meditation-naïve participants and participants who had taken part in an eight-week MBSR training. Furthermore, for the experienced meditator group alerting scores were correlated with prior meditation experience, with greater meditation experience correlating with reduced alerting scores (Jha et al., 2007).

Support for the interaction between emotion and attention can also be found

in various studies. Tang et al. (2007) found that after adults were given MT there were improvements in positive emotions and reduction in negative emotions as measured by the Profile of Mood States (POMS) questionnaire, indicating that participants gained more emotional self-regulation and control. A further study found that 15 minutes MT sessions could moderate emotional responses to affectively valenced picture slides compared to two active control groups who were either instructed to think about worrying thoughts or let their attention wander (Arch & Craske, 2006).

While the number of MT studies in children is still very limited, some studies have been done (see Table 1) and results will be reviewed shortly. Napoli and colleagues (2005) reported that MT improved selective attention and reduced anxiety in 1st, 2nd and 3rd grade children who participated in MT by the Attention Academy, compared to children from a reading-list control group. In clinical populations, MT has also shown to be effective for children with reading difficulties. Parents reported significantly reduced attention problems compared with parents of a waiting list control group (Semple et al., 2010). Furthermore, adolescents with Attention Deficit Hyperactivity Disorder (ADHD) reported reduction in self-reported ADHD symptoms, and showed improvements in measures of executive attention as measured by the ANT-I, a Stroop task and a Trail-making test (Zylowska et al., 2008). Finally, adolescents with ADHD, Oppositional Defiant Disorder (ODD)/Conduct Disorder (CD) and Autistic Spectrum Disorder (ASD) showed significant improvements in sustained attention on the D2 test of attention (Boegels, Hoogstad, van Dun, Schutter, & Restifo, 2008). However, no control groups were used for the latter studies and the findings should be viewed with caution. Finally, a case-report study reported improved alerting and executive attention rates on the ANT-I in children who had FA meditation experience of at least two years, when compared to meditation naïve children (Bajjal, Jha, Kiyaga, Singh, & Srinivasan, 2011).

While many of the above studies seem to indicate that MT has positive effects on children's attention and emotion, a note of caution is advised when interpreting these results. Firstly, as can be seen in Table 1, there is a wide discrepancy in methodology and study design, so a comparison between studies should be cautionary at the least. Secondly, most mindfulness studies involving children have focused on clinical populations; few have used typically developing populations. Thirdly, some studies suffer from methodological problems such as a lack of control groups, small sample sizes, and utilizing self-reports instead of performance tests or other more objective measures. Fourth and finally, there are vast differences in training programs that differ in content, length and duration of sessions. The present study was created in order to address some of the above shortcomings.

The Present Study

The present study will focus on the effects of MT on children's attentional capacities. Passive and active control groups will also be included.

1. The first hypothesis of this study states that compared to the active and the passive control groups, MT will lead to:
 - a) Improved attentional performance in the ANT-I (indicated by lower RTs) and
 - b) Larger increase in correctly solved sums on the Attentional Control Task.

Table 1: Overview of Studies Examining the Effects of MT on Attention in Children

Author(s)	Training study	Children's ages/ clinical diagnosis	Type of MT	Attentional Results
Bajjal, Jha, Kivanaga, Singh & Srinivasan (2011)	No training study	13-15 Non-clinical population	Concentrative meditation training	Alerting and executive attention, but not orienting, was found to differ between the CMT and the control group as measure by the ANT. Executive attention demonstrates age-related improvements.
Semple, Lee, Rosa & Miller (2010)	Training study	9-13 reading difficulties	MBCT-C	Children in mindfulness group showed significant reductions in attention problems on the Child Behaviour Checklist as rated by parents compared to controls.
Boegels, Hoogstad, van Dun, Schutter and Restifo (2008)	Training study	11-18 ADHD, ODD/CD and ASD	Adapted MBCT programme	Significant improvement on sustained attention was found as measured by the D2 test of attention
Zylowska, Ackerman, Yang, Futrell, Horton, Hale, Pataki & Smalley (2008)	Training study	8 adolescents & 15 adults with ADHD	MAPS for ADHD	Self-reported reduction in ADHD symptoms, improvements on measures of attentional conflict on ANT.
Napoli, Krech & Holley, 2005	Training Study	First, second and third-grade children non-clinical population		Self-reported reductions in anxiety as measured by the Test Anxiety Scale, and increase in selective attention as measured by two visual attention measures.

Furthermore, given that early meditation training seems to affect the executive control network and orienting network in particular,

2. The second hypothesis states children's mindfulness scores will have improved more in the executive control network and orienting network than in the alerting network.

Finally, due to the above reviewed links between emotion regulation and attention, as well as the fact that MT has often been reported to positively affect emotion regulation, we also investigated whether pre-existing differences in emotion control might have influenced training effects on attention measures.

3. The third hypothesis therefore states that children who display low emotional control at pre-training will have a larger increase in attention performance on the ANT-I after following the MT than children with high emotional control who follow the MT.

METHOD

Participants

The sample consisted of 29 children in fifth and sixth grades with a mean age of 10.8 years ($SD=0.85$), recruited from a primary school in Roermond (School 1), as well as 83 children recruited from a primary school in Swalmen (School 2) who had a mean age of 9.4 year ($SD=0.66$). Parents and school were briefed and signed a consent form. The study received ethical approval from a local Ethical Committee at the Faculty of Psychology and Neuroscience, Maastricht University. Completion of the program required that children attended at least 12 out of the 15 sessions. Nine children were excluded from the final data analyses due to parental refusal to sign the permission form or not attending enough sessions. For the ANT-I, the data of further 13 children was not usable due to technical problems with the equipment at pre-test and/or post-test sessions. After dropout, the data of 24 children was used in school 1 ($N_{\text{mindfulness training group}} = 12$, $N_{\text{active control group}} = 12$) and the data of 63 children was used from school 2 ($N_{\text{mindfulness training group}} = 24$, $N_{\text{active control group}} = 22$, $N_{\text{passive control group}} = 21$).

Design

The study used a non-randomized repeated-measures between-subjects design with one experimental group and one active control group in school 1 and one experimental, one active control group and one passive control group in school 2. Children were not randomly allocated to a group due to organizational constraints, so groups were determined by existing classes. One week before the start of training, participants and parents filled out the questionnaires for the pre-test, and within 2-3 weeks after completion of the training, post-test measurements were conducted.

Measures and Materials

Attention Network Test (ANT-I)

A previously adapted version of the Attention Network Test (ANT-I) (Callejas et al., 2004, 2005) was used to measure the capacities of the children's three attention networks (see Figure 1). This ANT-I differed in two regards to the ANT-I by Callejas and colleagues (2004, 2005): first of all, it used a more child friendly interface by using pictures of fishes instead of arrows. A similar design was used by Rueda and colleagues (2004) in their child-version of the ANT, and children were found to respond well to this design. Secondly, the stimulus onset asynchrony (SOA) between the alerting cue and the orienting cue was changed from 500 ms to 800 ms to account for children's slower processing times. The responses were collected via two keyboard keys (M and C). In every trial a fixation cross was held constant in the background. 24 trials were given in an initial practice round, followed by three blocks of 96 trials. After each block the child could briefly pause, and some form of encouragement ("well done" or "you're nearly there") was given.

The capacity of each network can be measured by calculating the mean Reaction Times (RT) in each condition and subtracting the relevant conditions from each other. Thus, the efficiency of the executive control network can be calculated by subtracting the mean RT across all congruent trials from the mean RT computed across all incongruent trials. The efficiency of the orienting network was inferred by calculating the difference between the mean RT across all validly cued target trials and the mean RT across all invalidly cued target trials (congruent and incongruent stimuli averaged). Finally, the effectiveness of the alerting network was determined by subtracting the mean RT on all uncued target trials from the mean RT on all cued target trials.

Attention Control Task

The Attentional Control Task was conducted immediately after the ANT-I, when children had already experienced some depletion on their attention networks. In the eight-minutes attention control task, children were required to calculate and write down the sum of digits presented on the computer screen before them. The sums increased in difficulty throughout the task. Children were subjected, through headphones, to auditory interferences in the form of a woman's voice randomly reading two or three digit numbers between eleven and 170. Children could solve a total amount of 40 sums, which was also the maximum number of correct sums that children could obtain in this task. Those children who had not completed the ANT-I due to technical failures were not included in the analysis. This task was previously used by Alberts et al. (2007), although it was used as a depletion task and not as a dependent measure. While the task does not measure the efficiency of individual attention networks, it was included since it was found to have high ecological validity as children are subjected to a lot of auditory interference in class while having to concentrate on their school work. Furthermore, using the percentage of sums solved correctly while correcting for the amount of sums solved in total, a dependent measure was easily found.

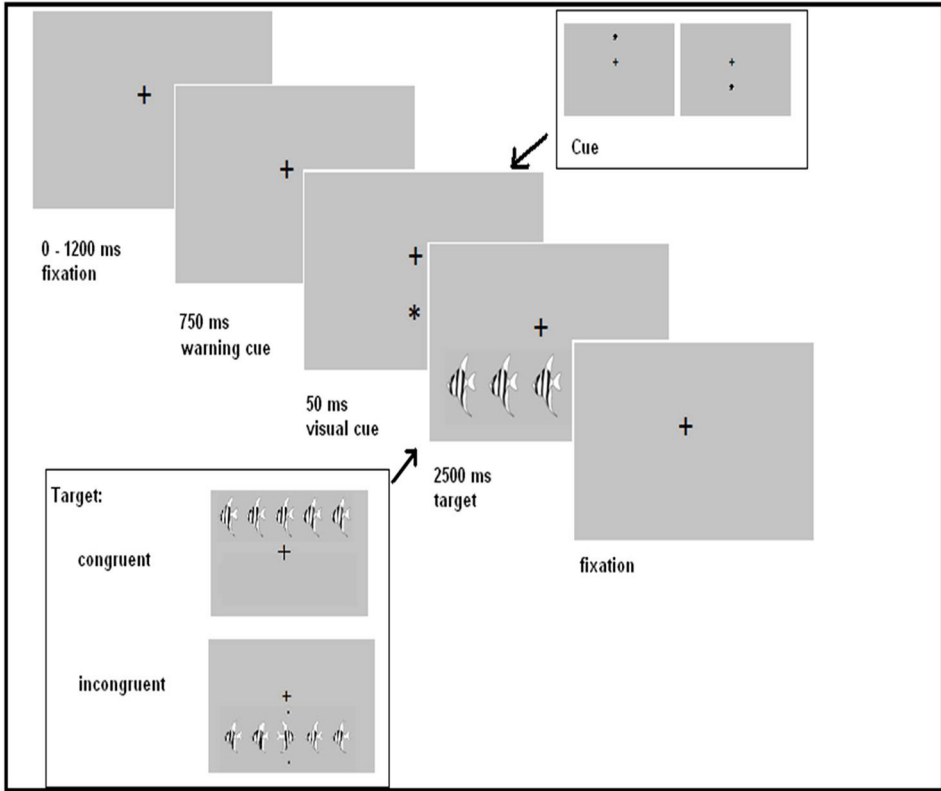


Figure 1: Schematic of the child version of the amended version of the ANT (Fan et al., 2002). In the actual test, the background colour is white.

Behavior Rating Inventory of Executive Function (BRIEF)

For all children, parental ratings of the Dutch BRIEF (Huizinga & Smidts, 2011) were taken at pre-test and at post-test. The BRIEF is a rating scale specifically developed to assess everyday executive skills of children aged five to eighteen in their daily environments such as home or school (Gioia et al., 2000). The parental version of the BRIEF has 75 questions using a three-point scale (Never, Sometimes, Often). 16 parents did not return the BRIEF at pre-training and the data was not included in the analysis. Since there were too few questionnaires returned by the parents at post-session it was not possible to analyze effects of the training on BRIEF-scores. The pre-training BRIEF scores on the Emotion Control were used to investigate whether emotion regulation behavior present before the training might influence training effects.

Procedure

In School 1, training took place from February to April 2012 and in School 2 training took place from March to June 2012. In School 2 training was paused for two weeks

as the school closed for Easter break. Two to three weeks before the MT and reading group began, questionnaires were given to the parents for completion and were collected the week before training. During testing sessions, the children were individually taken to a secluded room. Once the ANT-I had been explained they were given a practice round. Only children who had six or less mistakes of a total of 24 trials were allowed to proceed with the ANT-I; the others had to practice the trials again until they reached a 72% correct criterion. Completion of the ANT-I took no longer than 25 minutes in total. After performance on the ANT-I, children were tested on the Attentional Control Task. At the post-test, the same procedure was repeated.

Treatment

The experimental groups received the mindfulness teaching three times a week for 15 minutes for a five-week period. Thus, in total, children spent 45 minutes per week practicing mindfulness. Mindfulness training was given by trainers certified by Mindful Schools, an organization that adapted the MBSR course for children and that gives age-appropriate exercises and a fixed curriculum to their teachers.¹ A certified mindfulness teacher with at least two years experience in teaching Mindful Schools and four years experience in teaching Mindfulness taught the sessions to a whole class. During the course, children learned elements of FA meditation and OM meditation. Generally, the sessions would start with a Focused Attention meditation exercise (e.g. breathing with awareness) followed by theory about mindfulness, followed by an Open Meditation exercise. Afterwards, the children were asked to answer questions written on the board or reflect on the session by writing or drawing answers in a booklet. No homework was explicitly given, although children were encouraged to practice skills learned in the mindfulness group outside of sessions as well.

In the active control group, children were read a story from a book (School 1: "Artie in Artis" and "Dierenverhalen", School 2: "Artie in Artis" and "Otje"). Afterwards, the children reflected on the story or drew scenes from the book in their booklet. No homework was given in this group. No extra training was given for the passive control group in School B but the children participated in pre- and post-tests.

Statistical analysis

The study comprised an active controlled repeated measures between subjects design in which different groups of children were assigned to either mindfulness training or active/passive control groups. Children's mean network scores (computed as reaction time difference scores) on the ANT-I, parent-rated scores on the BRIEF and amount correct sums on the Attention Control Task were the dependent variables. For the computation of network scores in the ANT-I, trials with missing or incorrect responses were excluded from the analysis, as were trials with a RT under 200 ms. This was due to the fact that 100 ms - 200 ms is the time needed to process and respond, so responses faster than this can be seen as the

1 A copy of the relevant course can be accessed on their webpage: www.mindfulschools.org.

result of fast guesses (Whelan, 2008). Since children have a slower processing time than adults, the upper limit (200 ms) was chosen. Efficiency of the executive attention, orienting and alerting networks before and after training was estimated by computing subsystem difference scores as described before (see 2.3.1). This is a common method of analysis and has been reported in other papers (see e.g. Jha et al., 2007 and Fan et al., 2002).

To evaluate effects of the Mindfulness Training on the functioning of the three attention networks, these ANT-I subsystem difference scores were entered in a univariate repeated measures analysis of covariance (ANCOVA). Separate analyses for executive control, orienting and alerting were conducted with a Group factor and a Time factor. The Group factor either consisted of two levels at school 1 (MT group and AC group) or of three levels at school 2 (including MT, AC and a third passive control (PC) group). Age was included as a covariate because of the possible influence of age differences on network maturity. We also investigated the possible role of differences in pre-training levels of emotion control on effects of the training on the ANT-I. To get enough power in this analysis, only children from active control groups and mindfulness training groups (collapsed across schools) were included. Children from both groups were divided in two groups of subjects with either low or high emotional control on the basis of a median split on BRIEF-Emotion Control scores obtained pre-training within each group. The influence of this between group emotion control factor on training effects on ANT-I scores was examined in an ANOVA with two between factors: EmotionControl (high/low) and TrainingGroup (MT and AC). Post – pre ANT-I difference scores for orienting, alerting and executive control were entered in the ANOVA.

To evaluate the effects of Mindfulness Training on the Attention Control Task, an ANCOVA with one between group factor (Amount of Correct Sums) and one within group factor TrainingGroup (MT and AC) was conducted. To get enough power for this analysis, only children from MT groups and active control groups (collapsed across schools) were included. To control for children's numerical skills, the amount of correct sums at pre-test was entered as a covariate.

RESULTS

Effects of mindfulness training on Attention Network functioning

School 1:

The means of the RTs for correct responses in each experimental condition and for the different groups and different schools are presented in Table 2 and Figure 2. Before conducting the analysis an independent samples t-test showed there were no significant differences between the groups at pre-test for Executive Effect ($t(22) = .871, p = .393$), Orienting ($t(22) = .221, p = .310$) and Alerting ($t(22) = -1.328, p = .198$). It was thus decided to continue with the ANCOVA analysis. The ANCOVA analysis did not show a significant interaction of training and age. Further, there was no main effect of training group on mean RTs in Executive Control ($F(1,21) = 2.605$,

$p=.121$), Orienting ($F(1,21)=.139$, $p=.713$), and Alerting ($F(1,21)=.423$, $p=.522$). Since age did not explain variance in training effects on subsystem functioning, an ANOVA was conducted without age. Although mean RT Executive Control scores improve more from pre- to post-training in the MT group than in the AC group (see Table 2 and Figure 2), no significant effect of Training Group on mean RT of Executive Control ($F(1,22)=2.713$, $p=.114$), Orienting ($F(1,22)=.390$, $p=.539$) or Alerting ($F(1,22)=.880$, $p=.358$) was found. There was a main effect of Time for Executive control ($F(1,22)=13.350$, $p=.0014$) indicating that Executive Control scores decreased from the pre to the post measurement. However, the lack of interaction with Group indicates that this decrease was present in trained and untrained groups and thus was not specific for the MT group. No main effects of Time for Orienting and Alerting were found.

To check whether the alerting, orienting and executive control manipulations of the ANT worked in the sense that there were significant task effects (independent of the training) it was checked whether there were main task effects (e.g. invalid-valid, no tone-tone, congruent-incongruent differences). Significant main task effects were present for Executive Control ($F(1,22)=87.585$, $p<.0001$), Orienting ($F(1,22)=32.827$, $p<.0001$) and Alerting ($F(1,22)=79.363$, $p<.0001$). P-values were rounded up to maximal 4 decimals behind the comma.

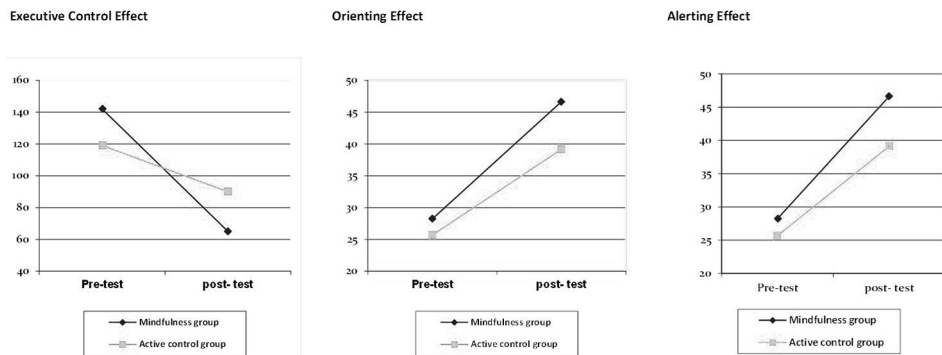


Figure 2: School 1 attention network effects in mean RT pre-test and post-test.

School 2:

Figure 3 displays the mean changes in RT from pre-test to post-test in the three attention networks. Since there were no statistically significant differences between group means at pre-test as determined by one-way ANOVA for Executive Control ($F(2,64) = 0.586$, $p = .559$), Orienting ($F(2,64) = 0.535$, $p = .588$) or Alerting ($F(2,64) = 0.496$, $p = .611$), it was decided to continue with the ANCOVA analysis. No interaction with age was found in the ANCOVA analysis, and there was no main effect of training group on mean RTs in Executive Control ($F(2,61)=1.822$, $p=.170$), Orienting ($F(2,62)=.092$, $p=.913$), and Alerting ($F(2,61)=.706$, $p=.497$). As age did not explain variance in training effects on subsystem functioning an ANOVA was

conducted without age as a covariate. No significant effect of Training Group on mean RT of Executive Control ($F(2,62)=1.880$, $p=.161$), Orienting ($F(2,63)=.090$, $p=.914$) or Alerting ($F(2,62)=.636$, $p=.533$) was found. There was a main effect of Time for Executive control ($F(1,62)=49.640$, $p=.0001$) indicating that Executive Control scores decreased from the pre- to the post-measurement but lack of interaction with Group shows that it was not specific for the mindfulness group. No main effects of Time for Orienting and Alerting were found.

To check whether the alerting, orienting and executive control manipulations of the ANT worked, we analyzed whether there were main task effects. Significant main task effects were present for Executive Control ($F(2,62)=349.720$, $p<.0001$), Orienting ($F(1,63)=22.659$, $p<.0001$) and Alerting ($F(1,62)=162.043$, $p<.0001$). P-values were rounded up to maximal 4 decimals behind the comma.

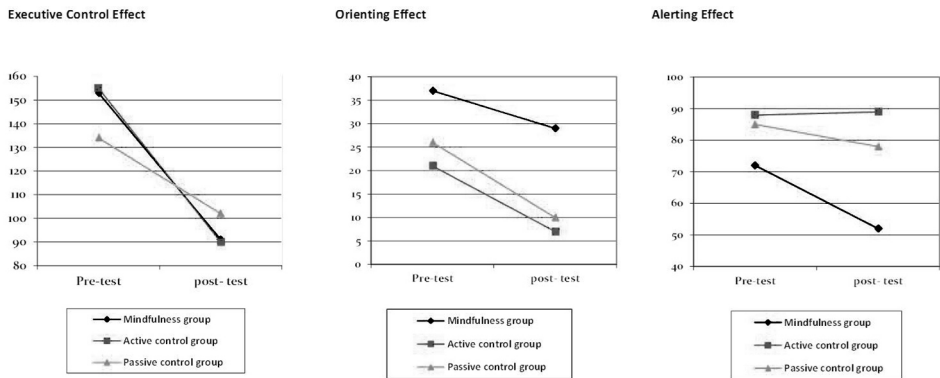


Figure 3: School 2 attention network effects in mean RT pre-test and post-test.

Effects of Mindfulness Training on the Attention Control Task

The mean number of correctly solved sums before and after the training in MT groups and AC groups (averaged over the schools) are presented in Figure 4. An ANCOVA analysis with pre-test scores entered as covariate and post-test scores as dependent measure showed no main effect of TrainingGroup on Amount of Correct Sums at post-test ($F(1,65)=1.276$, $p=.263$).

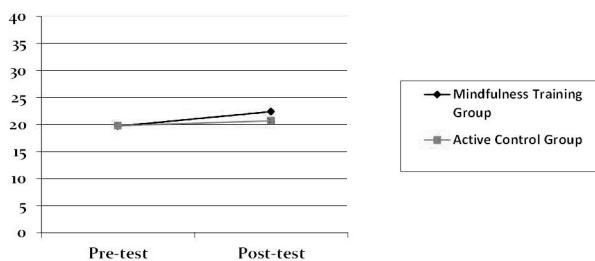


Figure 4: Mean amount of Correct Sums on the Attention Control Task from pre-test to post-test.

Effects of pre-training differences in emotion control on training effects.

A repeated measures ANOVA showed that no effects of pre-training Emotional Control levels (high/low) on effects of Training for the three subsystem attention network scores were present for Executive Control ($F(1,54)=.138, p= .712$); Orienting ($F(1,55)=1.273, p= .264$) and Alerting ($F(1,54)=.197, p= .659$). No main effects were found for Emotion Control on the subsystem attention scores of the ANT: Executive Control ($F(1,54)= .085, p= .772$), Orienting ($F(1,55)= .240, p= .626$) and Alerting ($F(1,54)= 1.252, p= .268$).

DISCUSSION**Discussion of results**

The goal of this study was to investigate the effects of mindfulness training on children's attentional control. We hypothesized that the mindfulness manipulation group would improve their attentional performance compared to a reading group and a passive control group which was tested too but did not receive training. Furthermore, we hypothesized that this change would be particularly evident in the executive control and orienting network, with the mindfulness group's mean reaction times decreasing more than the mean reaction times in the control groups after training. Finally, we hypothesized that children with low emotional control would benefit more from mindfulness training than children with high emotional control.

Unfortunately, these hypotheses could not be validated as children in the mindfulness groups did not perform significantly better than children in the reading groups or passive control groups on the attention tasks. Additionally, children's emotional control at pre-test in the mindfulness group was not predictive of their attentional performance on the ANT-I after mindfulness training. This is a somewhat surprising result given the number of studies that report positive changes in both children and adult's attentional capacities after mindfulness training (for example Jha et al., 2007; Tang et al., 2007; Chambers et al., 2008; Baijal et al., 2011; Semple et al., 2010; Napoli et al., 2005). Several explanations for this, ranging from methodological differences in mindfulness trainings to psychometric challenges, will be discussed below.

First, it is important to note that while none of the training effects were statistically significant, especially for the attention measures with a higher appeal on Executive control, they do indicate a trend in the predicted direction for changes in executive control. In the first school, the Executive control network scores (e.g. reaction times) decrease more from pre- to post-training measurement in the mindfulness group than in the control group, whereas this is not the case for the Orienting and Alerting networks. A similar trend was found in the second school where mean Executive control RT scores decrease more after training in the mindfulness group compared to the passive control group (but here there were no differences with the active control group). Furthermore, with respect to the attentional control calculation task, although not significant, the children in the

MT group did show a slight increase in correct sums after the training, whereas the control group did not. Since previous studies also report largest mindfulness training effects in the executive control network, this seems indicative that our results are going in the right direction.

However, for the executive control network all groups show an improvement with repeated measurement, leaving the possibility that a large part of the effect is due to practice on the task: repeated exposure to the task may have simply allowed the children to get better at it. Yet this would not explain why a similar trend cannot be found in the alerting or the orienting networks. However, the lack of finding a significant interaction cannot be due to a lack of task effects in the ANT-I since significant task effects during pre- and post-measurement were found for all three networks.

There are several possible explanations for not finding evidence that mindfulness training supports children's attentional skills. First of all, compared to the "traditional" mindfulness training courses, the curriculum offered by Mindful Schools is very short. In MBSR trainings, for example, participants receive up to 72 hours of mindfulness while children participating in the Mindful Schools curriculum only receive a total of 3.75 hours of mindfulness sessions. Other studies that also employed a shorter exposure time of mindfulness have also reported little or no results. For example, Anderson et al. (2007) reported no relationships between mindfulness and measures of sustained attention, switching, elaborative processing, or non-directed attention in adults. The authors themselves suggested that a longer mindfulness training course may have been more effective in producing improvements of attentional control. Furthermore, given that some studies have found a correlation between higher network scores on the ANT-I and experience in meditation (Jha et al., 2007), the fact that not enough time was spent practicing mindfulness seems quite likely.

Psychometric Problems

In the present study, the ANT-I was chosen as the instrument to measure attention since it is a commonly used instrument to distinguish three functionally different attention networks. Furthermore, prior studies have demonstrated its sensitivity for effects of brief behavioral interventions, such as Mindfulness trainings in adult populations (Tang et al. 2007). Rueda and colleagues reported in an article that previous studies had found that children respond well when there was a story and instant feedback, and had thus adapted their child-version of the ANT-I in this way (Berger, Jones, Rothbart, & Posner, 2000; Rueda et al., 2004). While the version of the ANT-I used in this study was presented to the children within a story (catching fishes), no feedback was given to the children beyond the practice round. This may have served as an additional motivator for children to answer questions more quickly, but it is likely that this would have been consistent in all groups, not just the mindfulness training group. Furthermore, there were highly significant task effects on reaction time for all three networks, showing that the ANT-I as a test worked well in our children. Finally, while this objection may explain some variation in the data it does not explain why the Attentional Control Task did not find significant results, and is thus not sufficient in itself to explain the above results.

Other problems

Finally, questions have been raised about the relative age of the children. Baijal et al. (2011) comment that monastic traditions that use elements of Mindfulness Trainings do not offer formal meditation experience to young monks until they reach early adolescence. It is possible that the Indo-Tibetan monastic tradition has experienced fewer benefits in teaching younger children to meditate, allowing the teaching of meditation to coincide with the increased maturation of the frontal cortex. A pilot study by Semple, Reid and Miller (2005) indicated that mindfulness-based techniques could be taught to children as young as 7 years old, citing decreased anxiety scores as rated by the children's teachers and the school psychologist after training. However, since the study was done with only five children and looks at observer-rated emotion scores rather than neuropsychological tests it is not enough evidence to conclude that mindfulness is truly effective at a young age. The question of age is one that remains to be answered by future studies.

CONCLUSION

Regardless of the above issues, this research raises a valid question whether mindfulness, in particular the Mindful Schools curriculum, is an effective way to support pre-adolescent children's attentional control. Given the amount of studies with adult populations reporting positive results, as well as a few children's studies which are certainly indicative of positive effects, it seems unlikely that children are completely unsusceptible to mindfulness training effects. One likely explanation for the results is the relative short time the children spent practicing mindfulness, compared to other studies which used longer training times and found positive changes in attentional control. Further research using a different mindfulness curriculum is recommended to fully assess the validity of this training.

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